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Impact of Expanded North Slope of Alaska Crude Oil Production on Crude Oil Flows in the Contiguous United States

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Abstract

The National Transportation Fuels Model was used to simulate a hypothetical increase in North Slope of Alaska crude oil production. The results show that the magnitude of production utilized depends in part on the ability of crude oil and refined products infrastructure in the contiguous United States to absorb and adjust to the additional supply. Decisions about expanding North Slope production can use the National Transportation Fuels Model take into account the effects on crude oil flows in the contiguous United States.

TABLE OF CONTENTS

FIGURES

TABLES

EXECUTIVE SUMMARY

Crude oil produced on the North Slope of Alaska (NSA) is primarily transported on the Trans-Alaska Pipeline System (TAPS) to in-state refineries and the Valdez Marine Terminal in southern Alaska. From the Terminal, crude oil is loaded onto tankers and is transported to export markets or to three major locations along the U.S. West Coast: Anacortes-Ferndale area (Washington), San Francisco Bay area, and Los Angeles area. North Slope of Alaska production has decreased about 75% since the 1980s,[1] which has reduced utilization of TAPS.

There is continued interest in expanding NSA production,[2] but this requires access to markets from Valdez, which is dependent on both demand levels and shipping/transport costs. The 2013 U.S. crude oil and refined product infrastructure was modeled using the National Transportation Fuels Model to test the potential for shipments from Alaska to increase to the West Coast, using hypothetical production in Smith Bay on NSA as a potential source of supply. Smith Bay production is purely hypothetical and does not represent actual development potential. Development of NSA fields such as Smith Bay can take a decade or more to complete. This analysis was designed only to represent modeling tools to aid in the development process and does not reflect the possibility of additional NSA production, which depends on a wide extent of other factors that must be taken into account as decisions about development are made.

The impacts of a hypothetical increase in NSA production are seen throughout the U.S. The primary effect is an increase in shipments from Alaska to Washington and California with local consumption. Because of the increase in supply from Alaska, both California and Washington reduce imports and Washington reduces rail shipments from the Bakken area. Therefore, distribution of Bakken crude changes slightly (Figure 1), which allows for crude oil storage inventories to increase throughout the country.

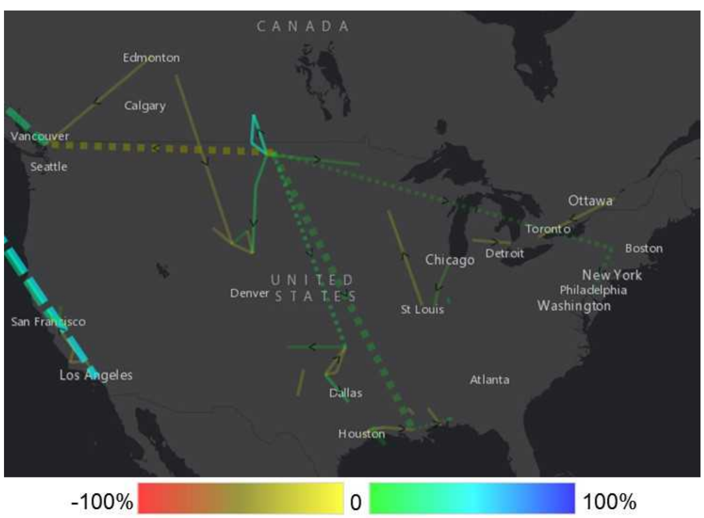

Figure 1. Percent change in crude oil flows on the 2013 National Transportation Fuels Model from before and after 200 Mbbl/day of hypothetical North Slope of Alaska production is added. Dashed lines represent rail/waterway links and solid lines represent pipeline links.

There appears to be a maximum amount of NSA oil that can be absorbed by California and Washington that is unrelated to port capacity, but is dependent on contiguous U.S. supply, demand, and storage patterns. As *capacity* of additional NSA production is exogenously increased in various scenarios, the *actual* amount of production does not increase linearly, as shown in Figure 2. This simulation does not factor in export market potential as a driver for actual magnitude of production.

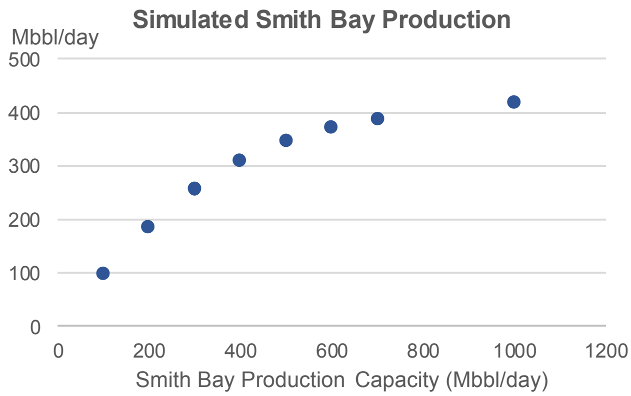

Figure 2. Simulated Smith Bay production on North Slope of Alaska as a function of production capacity using the 2013 National Transportation Fuels Model.

The analysis shows that expansion of NSA crude oil production must be considered in the context of interactions with the rest of the U.S. market. There are many factors when considering new development on NSA, but part of the decision-making process should include an understanding of the impact of additional production on crude oil and refined product flows throughout the U.S.

1. INTRODUCTION

Crude oil produced on the North Slope of Alaska (NSA) is primarily transported on the Trans-Alaska Pipeline System (TAPS) to in-state refineries and the Port of Valdez. In 2015, NSA crude oil production was 474 thousand barrels per day (Mbbl/day), 97% of the total Alaskan crude oil production.[3] North Slope of Alaska production has been declining over the last few years which is stressing operation of TAPS, as the pipeline system must maintain transport rates above about 300-350 Mbbl/day to remain in operation.[4]

There are two primary markets for NSA oil that is transported through TAPS to the Port of Valdez: (1) delivery to export markets or (2) shipment to ports on the West Coast of the U.S. If there is additional crude oil production on NSA, which is desirable to maintain operation of TAPS, the additional production must be absorbed by either of those two markets.

This analysis uses a national fuels model to simulate the effects of increased NSA crude oil production on shipments to the West Coast and then any resulting changes in crude oil flows throughout the contiguous U.S due to the changing West Coast flows. This modeling approach will estimate the hypothetical ability of shipments from Alaska to the West Coast based only on infrastructure capacity and operational decisions, not market conditions, tanker availability, crude quality, etc. Export markets in the Pacific are not included in this analysis, since those exports are very sensitive to global prices,[5] which are not included in this modeling approach.

2. METHODS

The National Transportation Fuels Model (NTFM) was used to simulate the effects of increased production of NSA crude oil on flows throughout the contiguous U.S. The NTFM is a network model of crude oil and refined products transportation in the contiguous U.S., Alaska, and portions of Canada. Crude oil infrastructure encompasses upstream representations of oil fields through to downstream distribution terminals. The network is composed of oil fields, refineries, tank farms, and terminals (network “nodes”) that are connected by pipelines, rail lines, and waterways (network “edges”). Flows of crude oil on the network are simulated based on a simplified model of market-based allocation where fuel is routed through the network to areas where it is most needed. Capacities of infrastructure components represent constraints on the system. The version of NTFM used in this work represents infrastructure at the end of 2013. For a complete discussion of NTFM design, data sources, and limitations see Wilson, Corbet, Baker, and O’Rourke 2015[6] and Beyeler, Corbet, and Hobbs 2012.[7]

3. SCENARIO DESCRIPTIONS

In October 2016, Caelus Energy Alaska, LLC announced a light oil discovery in Smith Bay on the North Slope. Estimated oil in place is 6 billion barrels and Caelus states that potential production could be 200 Mbbl/day of light oil into TAPS. However, Caelus has not announced any intention of development at this time. Development could take at least five to 10 years.[8] The location of Smith Bay in relation to TAPS and Prudhoe Bay is shown in Figure 3.

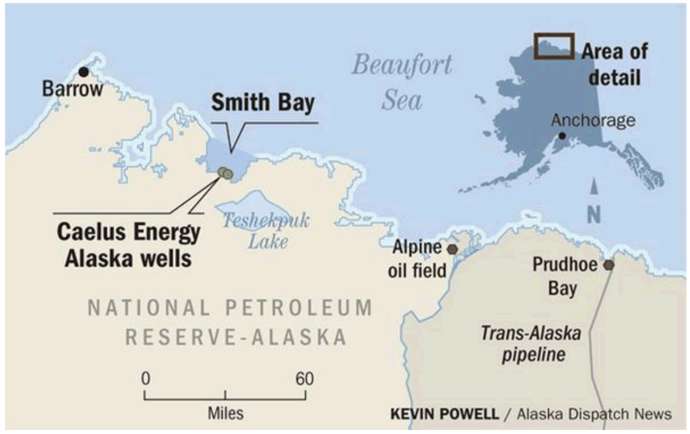

Figure 3. Map of the North Slope of Alaska. Source: Alaska Dispatch News.[8]

Four scenarios using NTFM were run to simulate operation of the crude oil and refined products network with different levels of production from Smith Bay:

1. 100 Mbbl/day Scenario: NTFM with 2013 infrastructure, production, and consumption and 100 Mbbl/day of Smith Bay production beginning on day 10.
2. 200 Mbbl/day Scenario: NTFM with 2013 infrastructure, production, and consumption and 200 Mbbl/day of Smith Bay production beginning on day 10.
3. 300 Mbbl/day Scenario: NTFM with 2013 infrastructure, production, and consumption and 300 Mbbl/day of Smith Bay production beginning on day 10.
4. 400 Mbbl/day Scenario: NTFM with 2013 infrastructure, production, and consumption and 400 Mbbl/day of Smith Bay production beginning on day 10.

Each scenario starts with nine days of baseline behavior before Smith Bay production is introduced on day 10.

3.1. Scenario Limitations

All of these scenarios use the 2013 NTFM, but Smith Bay development may take 10 years or more to come online. During the development time period, significant infrastructure and market changes may occur in the U.S. and throughout the world that will affect these results. The NTFM also does not include exports of crude oil, which have increased since ending the crude oil export ban in 2015.

4. RESULTS

As Smith Bay production increases in moving from Scenario 1 through Scenario 4, there is an increase in flow through TAPS and then waterway shipments from Valdez to Washington and California. There are two secondary effects seen because of this change: (1) rail shipments of crude oil from the Bakken area to Washington decrease, and (2) crude oil in storage throughout the country slowly increases over the scenario duration. The single primary effect of Valdez to West Coast shipments and the two secondary effects are discussed below.

4.1. Shipments from Valdez to Washington and California

Crude oil produced on NSA is transported through TAPS to Alyeska's Valdez Marine Terminal in Prince William Sound. From the Terminal, crude oil is loaded onto tankers and is transported to three locations along the West Coast: Anacortes-Ferndale area (Washington), San Francisco Bay, and Los Angeles area.

All three tanker routes show increases in volume shipped in all four scenarios with Smith Bay production. As Smith Bay production capacity increases, these waterway shipments increase nonlinearly.

4.1.1. Valdez to Anacortes-Ferndale

Baseline shipments from Valdez to the Anacortes-Ferndale area are 260 Mbbl/day. When Smith Bay production is added, shipments along this route begin increasing immediately and level out asymptotically within about six months, as shown in Figure 4. In the scenario with Smith Bay production capacity of 200 Mbbl/day, an additional 63 Mbbl/day are supplied to Anacortes-Ferndale from Valdez.

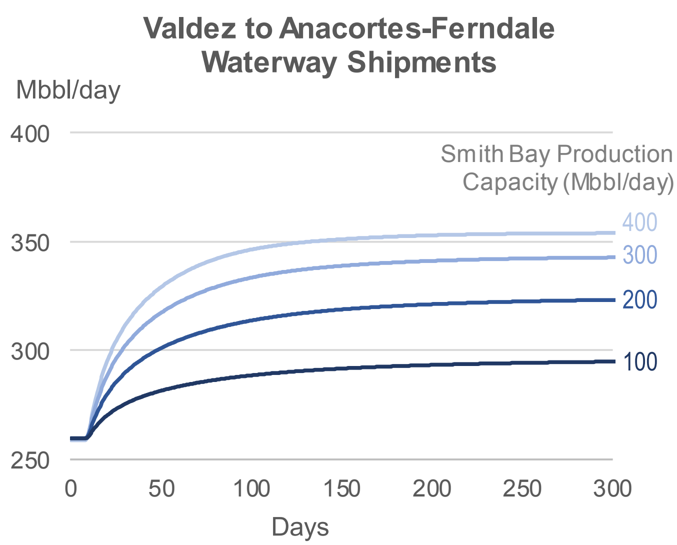

Figure 4. Simulated waterway shipments from Valdez to Anacortes-Ferndale with four different levels of Smith Bay production capacity beginning on day 10.

As a result of the increased crude oil supply to Anacortes-Ferndale, imports of crude oil from Edmonton, Canada to Anacortes-Ferndale by pipeline decrease slightly, as shown in Figure 5. In the scenario with Smith Bay production capacity of 200 Mbbl/day, the decrease in Edmonton imports is 2 Mbbl/day. This quantity of decreased imports, is not equal to the magnitude of additional supply (63 Mbbl/day).

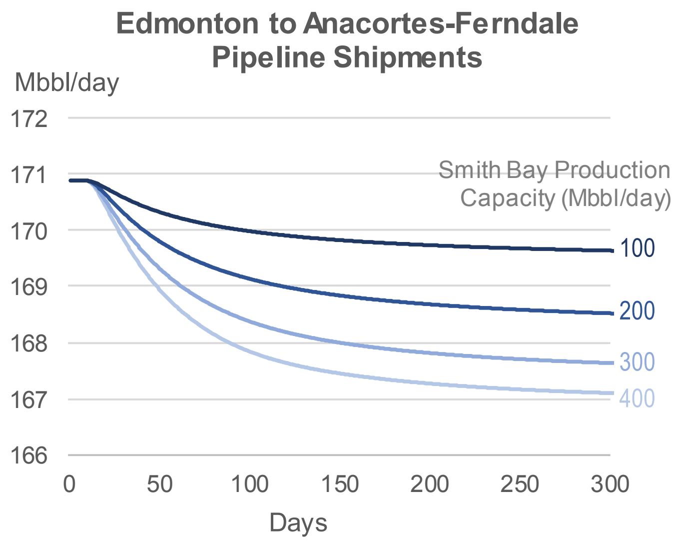

Figure 5. Simulated pipeline flows from Edmonton to Anacortes-Ferndale with four different levels of Smith Bay production capacity beginning on day 10.

4.1.2. Valdez to California

Baseline shipments from Valdez to the San Francisco area are approximately 100 Mbbl/day, shipments to the Los Angeles-Long Beach area are also approximately 100 Mbbl/day. When Smith Bay production is introduced, shipments peak in the first month, followed by a decrease to a stable amount as shown in Figure 6. In the scenario with Smith Bay production capacity of 200 Mbbl/day, an additional 30 Mbbl/day are supplied to San Francisco from Valdez and an additional 50 Mbbl/day are supplied to Los Angeles-Long Beach from Valdez.

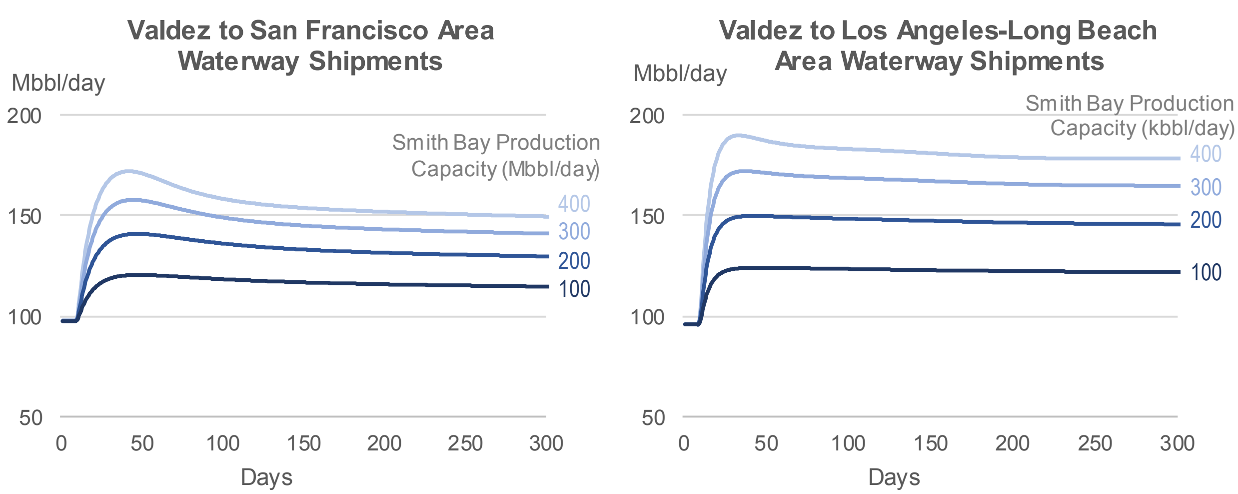

Figure 6. Simulated waterway shipments from Valdez to the San Francisco and Los Angeles-Long Beach areas with four different levels of Smith Bay production capacity beginning on day 10.

As a result of increased supply to California from Valdez, both San Francisco and Los Angeles reduce their imports of crude oil, but not by the same magnitude of additional Valdez supply. In the scenario with Smith Bay production capacity of 200 Mbbl/day, imports are reduced by about 12 Mbbl/day in San Francisco and 40 Mbbl/day in Los Angeles-Long Beach. Import levels for both locations are shown in Figure 7.

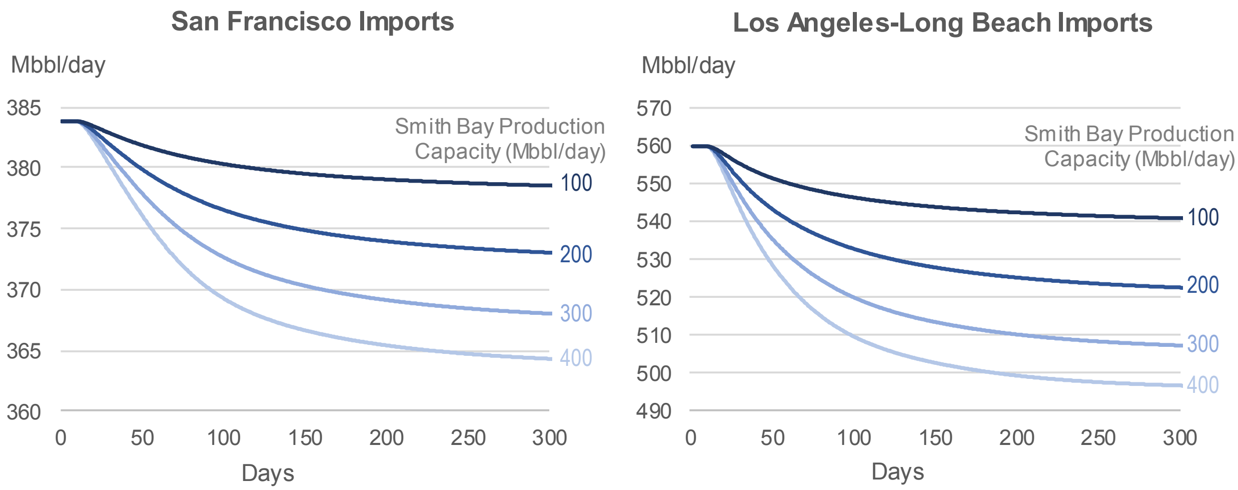

Figure 7. Simulated imports to San Francisco and Los Angeles-Long Beach areas with four different levels of Smith Bay production capacity beginning on day 10.

4.1.3. Limit of Valdez Shipments to Washington and California

As Smith Bay production capacity increases, there appears to be a maximum amount of crude oil actually produced and then shipped to Washington and California, as linear increases in production capacity do not show a linear magnitude of increased shipments in Figure 5 and Figure 6. This is unrelated to port and terminal capacity in Washington and California, as capacities are substantially higher than any shipments seen in these results. As *capacity* of additional NSA production is exogenously increased in various scenarios, the *actual* amount of production does not increase linearly. The level of diminishing returns for actual Smith Bay production, despite increases in production capacity, occurs at just above 400 Mbbl/day and is shown in Figure 8. As production capacity increases, the amount of actual production does not increase linearly.

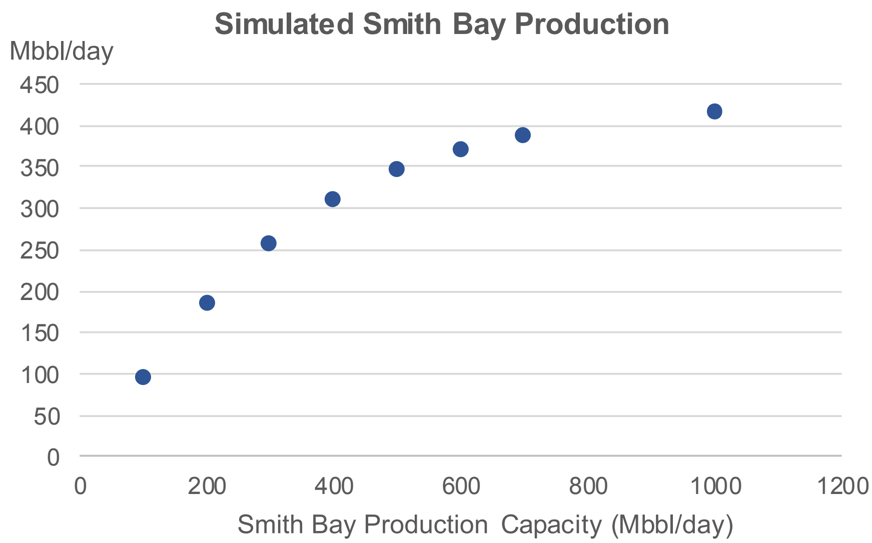

Figure 8. Simulated Smith Bay production as a function of available capacity.

4.2. Rail Shipments from Bakken to Washington

As Valdez shipments to Washington increase, the first effect is a reduction in rail shipments from the Bakken area to Washington. In the scenario with Smith Bay production capacity of 200 Mbbl/day, three days after the introduction of that capacity (ignoring shipping times), Bakken shipments to the Northwest start to decrease. Throughout the simulation, the shipments stabilize at about 55 Mbbl/day, down from an initial level of 105 Mbbl/day as shown in Figure 9.

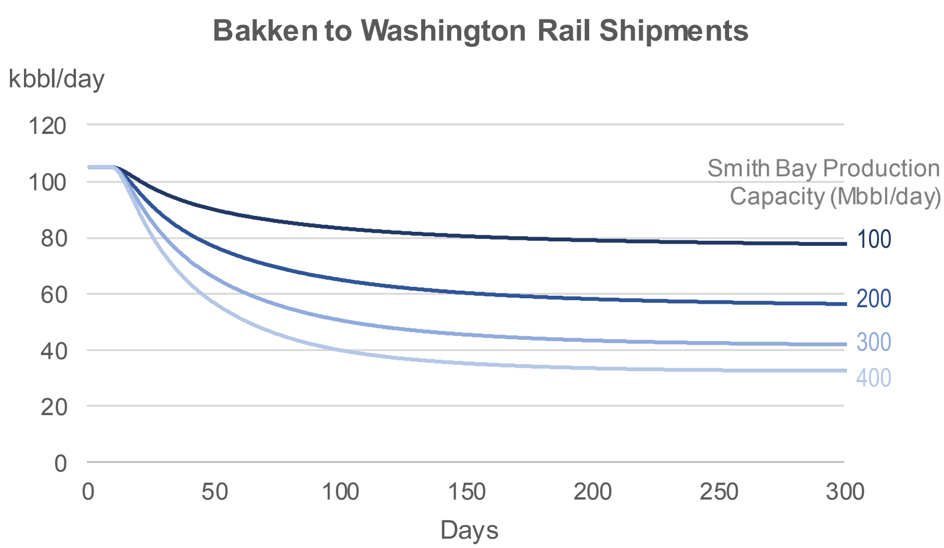

Figure 9. Simulated quantity of rail shipments of crude oil from the Bakken area to Washington with four different levels of Smith Bay production capacity beginning on day 10.

As Bakken shipments to Washington decrease, there is a small excess of crude that remains in the Bakken area and affects the magnitude of crude oil flows from the Bakken to other regions around the U.S. The extent of impacts is illustrated in Figure 10.

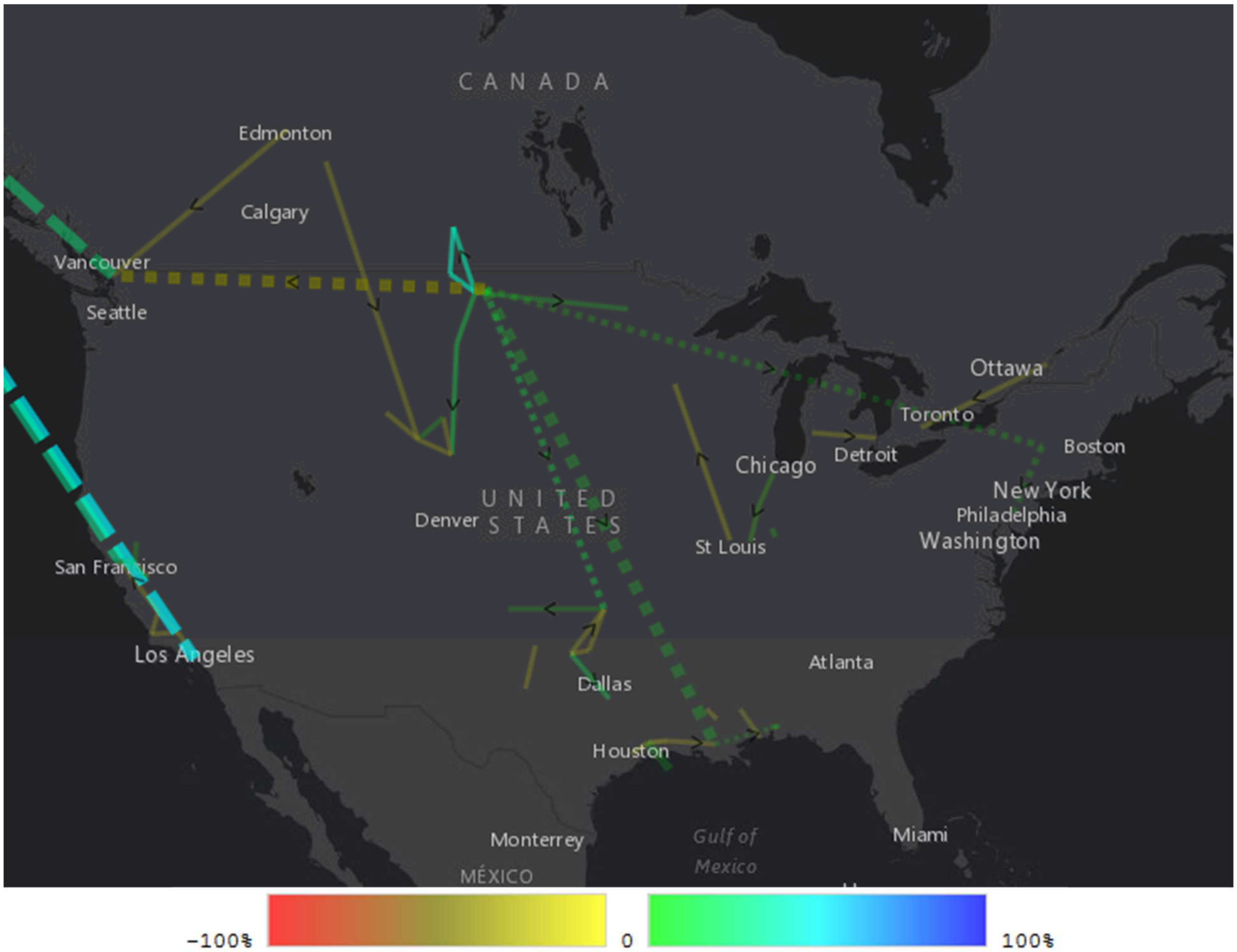

Figure 10. Simulated changes in crude oil flow resulting from changes in decreased Bakken to Washington rail shipments for the scenario with Smith Bay production capacity of 200 Mbbl/day. Solid lines represent pipeline flows and dashed lines represent waterway/rail connections.

Flow from the Bakken increases slightly on (1) the Butte pipeline towards Wyoming (20 to 24 Mbbl/day; 20% increase), (2) the North Dakota System towards Clearbrook (132 to 138 Mbbl/day; 5% increase), (3) rail towards New York (104 to 106 Mbbl/day; 2% increase), (4) rail towards St. James Terminal (304 to 322 Mbbl/day; 6% increase), and (5) rail towards Cushing (49 to 56 Mbbl/day; 14% increase). The largest percent change in flow occurs from the Bakken towards Regina-Cromer pipeline station on the Enbridge Bakken Expansion (23 to 32 Mbbl/day; 39% increase).

4.3. Crude Oil in Storage

The additional crude oil from Valdez being accepted in California and Washington is not completely replacing all imports, so crude oil in storage increases slightly in all four scenarios. The largest percent increases in crude oil in storage occur in California, but storage changes are seen in small levels around the country due to changes in flow emanating from the Bakken (Figure 11 and Figure 12).

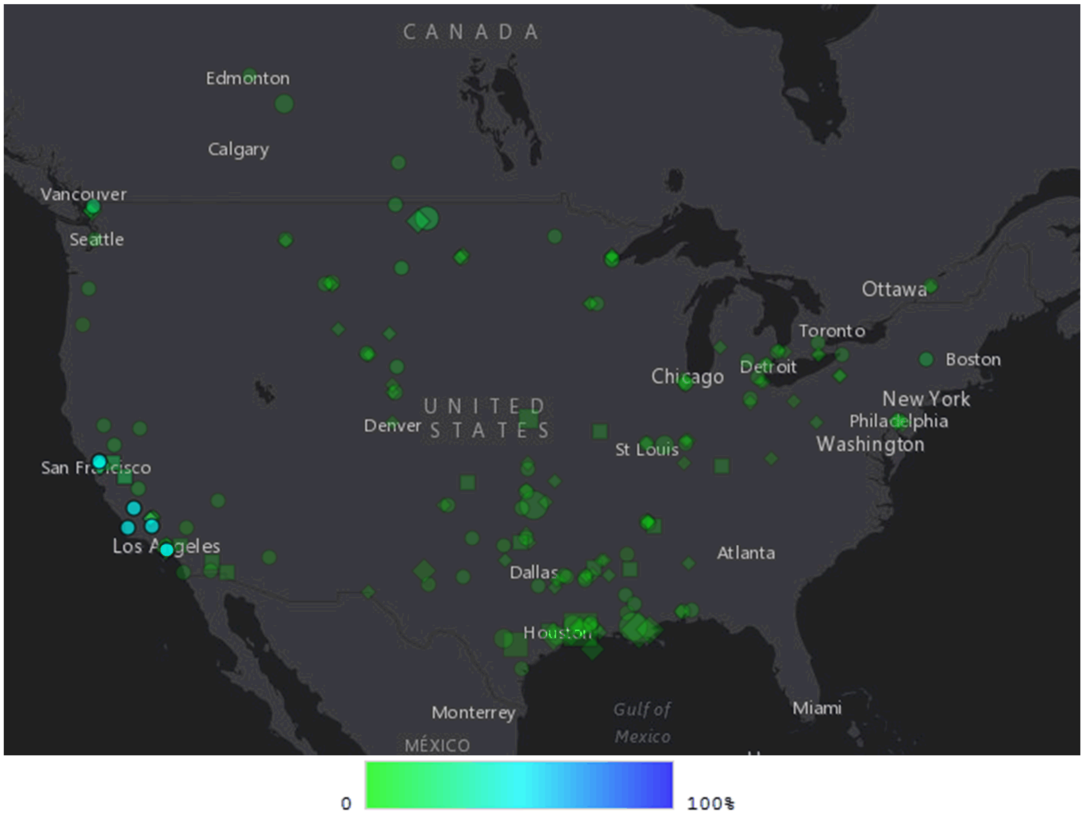

Figure 11. Change in crude oil in storage between day 0 and day 365 with Smith Bay production capacity of 200 Mbbl/day beginning on day 10.

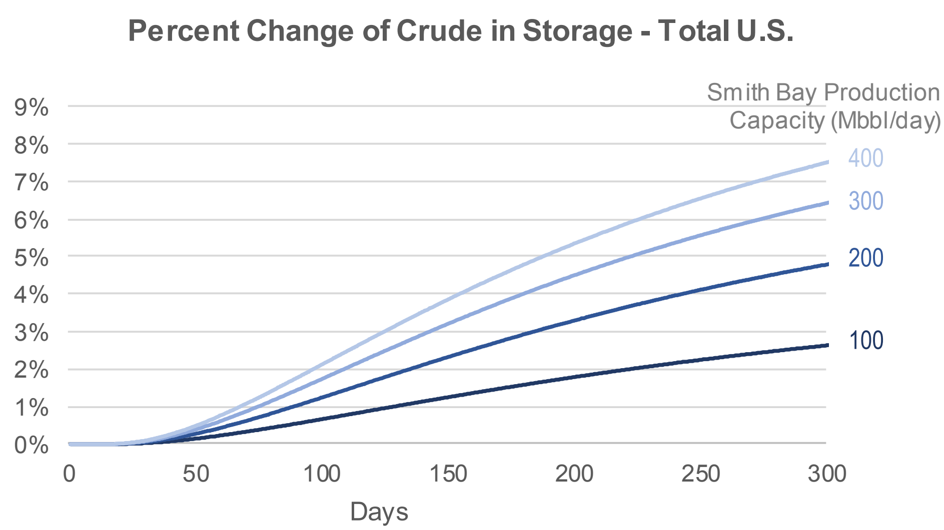

Figure 12. Simulated additional volume of crude in storage for the U.S. with four different levels of Smith Bay production capacity beginning on day 10.

The distribution of storage increases by Petroleum Administration for Defense District (PADD) is shown in Table 1.

Table 1. Simulated change in crude oil in storage by PADD after one year with four different levels of Smith Bay production capacity beginning on day 10.

		Smith Bay Production Capacity Scenario (Mbbl/day)			
		100	200	300	400
Region	PADD 1	4%	8%	11%	12%
	PADD 2	3%	6%	8%	9%
	PADD 3	3%	6%	7%	9%
	PADD 4	3%	5%	7%	8%
	PADD 5	3%	5%	6%	7%
	Total U.S.	3%	6%	7%	8%

5. CONCLUSIONS

The National Transportation Fuels Model was used to simulate the impact of increased NSA crude oil production on flows of crude oil and refined products throughout the contiguous U.S. While the analysis does not indicate the timeframe or possibility of NSA developments, it does indicate that impacts on contiguous flows can be an important factor to consider when making NSA development decisions. The ability of increased production to be used in the West Coast market is not only dependent on transport and port capacity, but also relies on secondary flow patterns such as Bakken area production and transport. Changes in import levels, Bakken flows, and storage inventory are all seen in these simulations as NSA production increases. This analysis shows that future NSA production development decisions can use the NTFM to take into account the impact of changes in flows throughout the contiguous U.S.

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